

IMPACT OF LAND USE AND LAND COVER CHANGE ON AGRICULTURE PRODUCTION IN MUHANGA CITY

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Abstract: Cities that are being built worldwide. This is a major driving force for the Land Use/Land Cover Changes that is plaguing our world insidiously. Such changes impact the Agricultural sector and limit the availability of products and services for human and livestock. Environmental Health is also impacted. Unfortunately, much information is not documented regarding the relationship between LULC Change and the Agricultural production within Urban and Rural Areas. This study, therefore, is aimed at demonstrating this relationship by considering the agricultural production in Muhanga City, Rwanda. Time-series satellite images that included Landsat ETM+ were used for likelihood classification of LULC. Socio-economic Survey, interviews and review of documents were carried out to understand historical trends. Ground truth points were collected and other secondary information required. Analysis of data was accomplished through the use of ERDAS imagine (version 9.1) and ArcGIS (version 10.8) software packages along with Microsoft office analytical tools. Remote sensing analysis gave us the status of change of cultivated land to have a net increase in Muhanga city while agricultural statistics has showed agricultural production has decreased between 2002 and 2022. The study also revealed that the study area has lost some 22.3% (1365.75 ha) of cultivated land to urbanization (Built-up) between 2002 and 2022. At the same time built-up has increased about 16.9 % (1034.58 ha). The LULC changes have also destroyed forested land in the study area. These are also the dominant crops cultivated in Muhanga city. It revealed that Many crops yields were reduced as indicated: Maize reduced from 571 Kg to 541kg, Cassava from 1345 to 1040 kg, Rice from 394.7 to 387 kg, Ordinary Beans from 640.6 to 490 kg, Climbing Beans from 747 to 736 kg, Peas from 116 ha to 70 kg, Vegetables from 3716 kg to 3523 kg, Soybeans from 70 kg to 22 kg, Banana from 1695 kg to 1115 kg, Irish potatoes from 313.9 to 225 kg, Sweet potatoes from 181.9 kg to 152 kg, Fruits from 78 to 89kg and Coffee 52 to 17 kg. Continuous monitoring of LULC changes and their impacts are still recommended.

Keywords: Land use and land cover change, Agriculture production, Satellite image, GIS, impacts.

1. Introduction

The relationship between Agricultural Production and Land Use/Land Cover Changes cannot be ignored as there is an exponential rate of urbanization (Pandev & Seto, 2014). Geospatial Technologies

(including Remote Sensing, Landsat Satellite, Geographic Information and Global Position System) are useful in the study of the above mentioned correlation as they provide information and opportunities to understand and quantify the rate of changes occurring on the earth's surface

over time (Khan et al., 2016; Seto et al., 2004). In developing countries like Rwanda, Land use and land cover change (LULCC) is the conversion of different land use types, and is the result of complex interactions between humans and the physical environment (Halefom et al., 2018; Negassa et al., 2020). LULCC is a major driver of global change and has a significant impact on ecosystem processes, biological cycles and biodiversity.

The government of Rwanda (GoR) has decided to increase the urbanization rate up to 35% in 2024. To achieve this target, Muhanga, one of the six secondary cities to Kigali has been under development whereby this has been characterized by the expansion of built-up areas in the city of Muhanga (WorldBank, 2017). Considering the potential link between LULCC and agriculture, an understanding of the agricultural production of the major cities, such as Muhanga City, that are highlighted in this increased urbanization is imperative. This study mapped and analyzed the impact of land use and land cover changes on

agricultural production in Muhanga City between 2002 and 2022. It specifically focused on the following: (1) mapping and analyzing the land use land cover of Muhanga City between 2002 and 2022; (2) determining the agricultural production in Muhanga City between 2002 and 2022; and (3) investigating the impact of Land Use and Land Cover Changes on Agricultural crop production in Muhanga City between 2002 and 2022

The methods and materials used, Section II; the results obtained, Section III; the discussion and analysis of results, Section IV; and, finally, the conclusion, Section V are all discussed succinctly by the researcher in the ensuing sections as indicated.

2. Methods and Methodology

2.1. Study Area

Muhanga City is a secondary city located in central Rwanda, approximately 45 kilometers southwest of Kigali, and it is officially a part of the Southern Province.

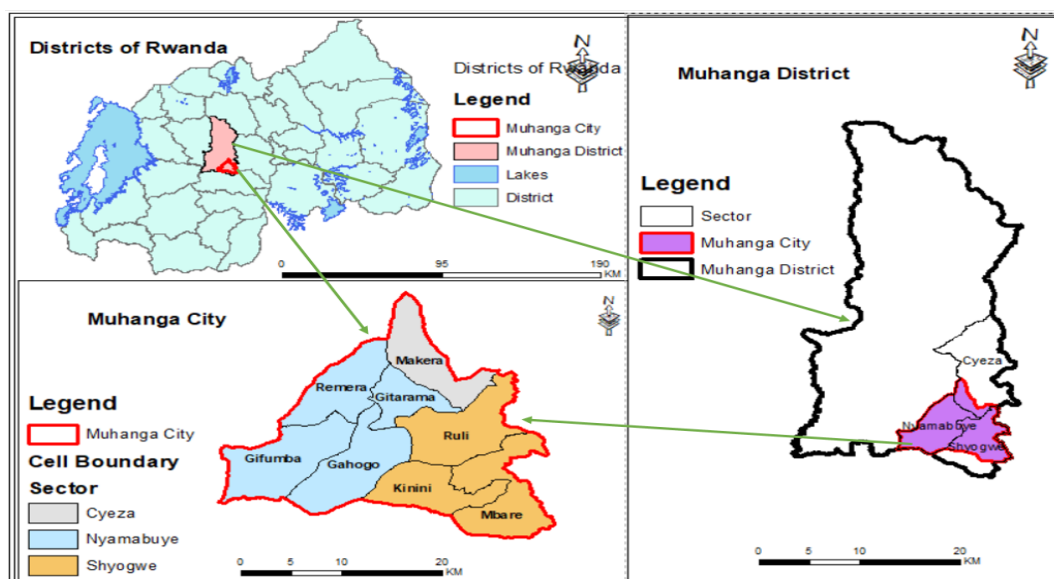


Figure 1: Map of Muhanga City

2.2. Study Design

This study has a Cross-sectional Design. The Researcher collected data on the LULC and the Agricultural Production of Muhanga City using Landsat Satellite and Data from the Agronomy Department of Muhanga District and MINAGRI respectively.

2.3. DATA Collection Methods

There was a collection of qualitative and quantitative information to better understand, explain, and interpret the agriculture production and land use and land cover change. These techniques include Satellite imaging, GIS and GPS. Satellite imaging, GIS (Geographic Information Systems) and GPS (Global Positioning System) techniques are used for the study of land use pattern. Ground trothing points in the study area was collected to aid different steps of image processing and classification for change detection. Besides this, field observation was made to have better information about the nature of the various land use and land cover classes prevailing in the study area.

2.3.1. Field visit

Field visits on the study area were made in the study area to document existing situation and collect ground points using global positioning system device and taking some photos.

2.3.2. Desk Review

Desk review involved reading scientific articles, books and reports about Land use land cover changes and their impacts. Reading published materials on urbanization and land use land cover changes contribute to a better understanding of impacts LULC Changes and its impacts. Furthermore, desk review involved exploring the existing data,

publication and research articles from either Library or internet.

2.4.Data required and sources

2.4.1. Satellite Images

The Landsat images for the years 2002-2022 will be collected from USGS through their earth explorer web portal (<https://glovis.usgs.gov/>) and were used for image classification to identify land use patterns and create LULC maps and LULC changes. Landsat-5 satellite images were obtained for 2002 and Similarly, Landsat-8 satellite images were acquired for 2012 and 2022. The Landsat images had the spatial resolution for 30 m. Images with cloud cover of less than 5% were only be selected to maintain quality and uniform weather conditions throughout the study period.

2.4.2. Agricultural data

Data on Crop wise productivity in kilogram per hectare in study period was collected from MINAGRI and Muhanga District. Information for the yield per hectare data for the main crops grown in Muhanga City was also collected from government agencies in charge of agriculture or statistics. Any other data related to Agriculture production, cropping and grazing activities was sourced from MINAGRI/RAB

2.4.3. Spatial data

Administrative data and city shape file were acquired from Rwanda housing Authority and National institute of statistics of Rwanda (NISR).

2.5.Data Analysis

Having LULC maps and results from detected changes in Muhanga City, a comparison and analysis was made using

maps and statistics from the classification and post-classification. Here the ArcMap 10.8 will be used to make maps while ERDAS imagine was used to determine the Changes in LULC over time (from 2002 to 2022). These findings were interpreted and impacts of the LULC changes on other land cover and land use were assessed.

By using the EXCEL, Data from MINAGRI and Muhanga District or other institutions were analyzed then linked to statistics from the change detection.

Information on agriculture crop production over the study period were assessed and linked to agricultural land cover from the

classification using Advanced EXCEL (MS)

3. Results

For the purpose of observing the land use land cover of the study area, it is undoubtedly paramount to select major classes relative to the study area. The classes selected are built-up land, Forested land, barre land, Cultivated or agricultural land water body

The contingency table, inserted below, obtained from the remote sensing based-classification shows the extent of each type of land use/ cover class at different study periods of the area.

Table 1: LULC Changes in Muhanga from 2002-2022

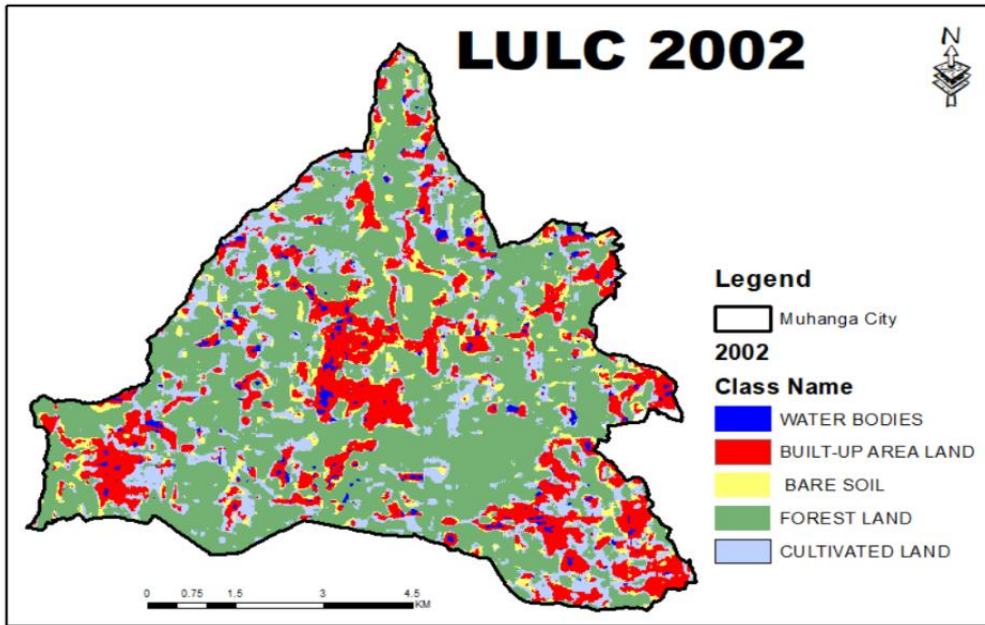
LULC Classes	2002		2012		2022	
	Area in Ha	%	Area in Ha	%	Area in Ha	%
BUILT-UP AREA LAND	1108.057748	18	1880.604803	31	2142.64	35
CULTIVATED LAND	2554.938956	42	1460.23811	24	1189.19	19
FOREST LAND	1911.43	31	1864.77	30	1688.79	28
BARE SOIL	418.144463	7	603.99	10	998.43	16
WATER BODIES	125.423651	2	308.390783	5	98.94	2
Total Area(Ha)	6117.99	100	6117.99	100	6117.99	100

Source: Classification statistics by the researcher, 2022

3.1.LULC of Muhanga in 2002

The result obtained from the classified Landsat image of 2002 shows that the dominant land cover of the study area

within this period is cultivated land which account 42% of the total study area. This is followed by Forested land, Built-up, Bare land and Water Body which account 31%, 18%,7% and 2 % respectively.



1.1.LULC of the Study Area in 2012

The result obtained from the classified Landsat image of 2012 show that; the dominant land cover of the study area within this period is Built-up which account 31% of the total study area. The other

dominant land cover class forested land, Cultivated land, Bare land and Water Body which account 30%, 24%,10% and 5 % respectively.

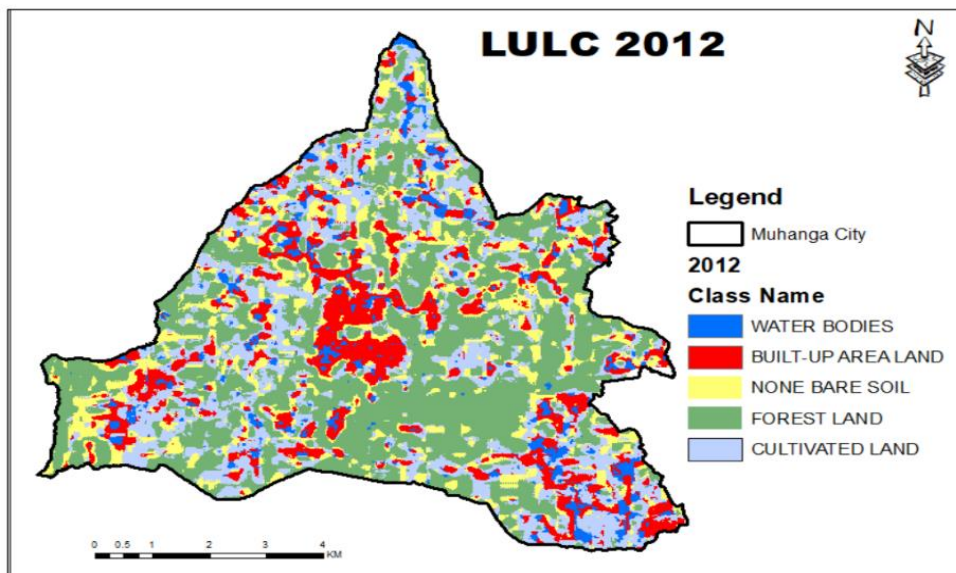


Figure 3: Muhanga City LULC 2012

1.2.LULC of the Study Area in 2022

Classification showed that Landsat image of 2022 show that; the dominant land cover of the study area within this period is Built-up which account 35% of the total study

area. The other dominant land cover class forested land, Cultivated land, Bare land and Water Body which account 28%, 19%,16% and 2 % respectively (Figure 4)

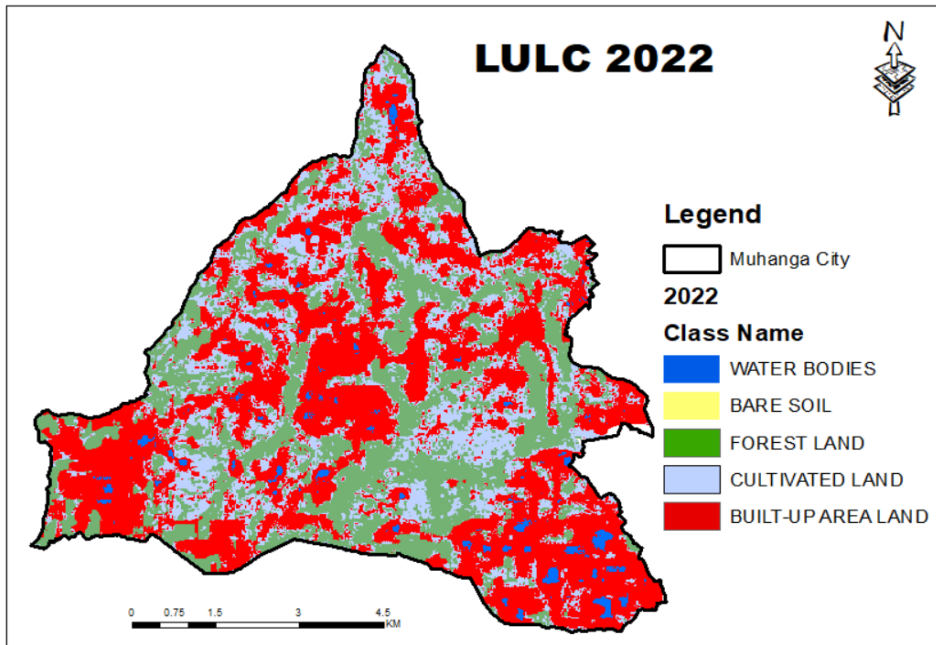


Figure 4: Muhanga City LULC 2022

1.3.LULC change between 2002 to 2022

Generally, the LULC types in the three study periods gradually changed with differing rates depending on the existing socio-economic, political, and environmental situation. Considering the

overall study period (20 years), there was a remarkable increase in a real extent of built up area of land from 1108.06 ha (18 %) in 2002 to 2142.64 ha (35%) in 2022. Cultivated land, and Forested land were diminished at a higher rate within these 20 years (Figure 5)

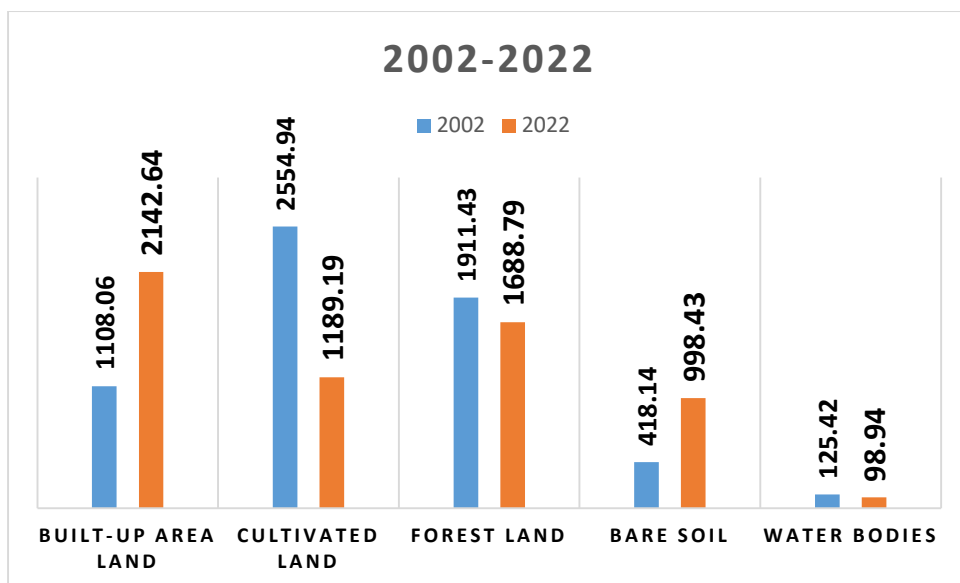


Figure 5: Variation of Muhanga City LULC from 2002 to 2022

1.4. Agricultural production in Muhanga City.

Based on the information from District and sectors agronomist, it was indicated that farmers from Muhanga city mainly grow following crops: Maize, Cassava, Rice, Ordinary Beans, Climbing Beans, Peas, Vegetables, Soybeans, Banana, Irish potatoes, Sweet potatoes, Fruits and Coffee. It was indicated that more than a half of the farmers cultivate cereals, beans, Potatoes, Cassava, sweet potatoes and soya and vegetables. These crops constitute about

95% of food stuff found in most of the markets within the city and beyond. This demonstrates the immense contribution of Muhanga City in food supply in Southern Province.

1.5. Agricultural Production in 2002

Based the agricultural statistics from the District of Muhanga for the year 2002, it was mentioned that the production was huge for the following crops: Vegetables, banana and Cassava with 3716 kg, 1695 kg and 1345 kg of production per each household respectively (Table 2)

Table2: Statistics on agricultural Production in 2002

Agricultural production of each Sector per Household				
Year 2002	Nyamabuye	Shyogwe	Cyeza	Total (Kg)
Maize	106	213	252	571
Cassava	459	488	398	1345
Rice	185	77.7	132	394.7
Ordinary Beans	305	279.6	56	640.6
Climbing Beans	231	255	261	747
Peas	36	41	39	116
Vegetables	1230	1247	1239	3716
Soybeans	12	24	34	70

Banana	306	690	699	1695
Irish potatoes	74.9	112	127	313.9
Sweet potatoes	27.9	56	98	181.9
Fruits	21	12	45	78
Coffee	7	16	29	52

Source: Muhanga District and MINAGRI, 2002

1.6. Agricultural Production in 2012

The analysis from the agricultural statistics from the District of Muhanga for the year

2012, it was mentioned there was an increase on the production in almost all crops (Table 3)

Table 3: Statistics on agricultural Production in 2012

Agricultural production of each Sector per Household				
Year 2012	Nyamabuye	Shyogwe	Cyeza	Total (Kg)
Maize	120	213	252	585
Cassava	678	675	543	1896
Rice	207	180	132	519
Ordinary Beans	309	3011	56	3376
Climbing Beans	165	180	209	554
Peas	10	23	19	52
Vegetables	1235	1413	1321	3969
Soybeans	26	21	36	83
Banana	342	234	312	888
Irish potatoes	90	113	130	333
Sweet potatoes	35	45	87	167
Fruits	28	23	38	89
Coffee	7	15	26	48

Source: Muhanga District and MINAGRI, 2012

1.7. Agricultural Production in 2021.

The data we got from the agronomists of the Districts and MINAGRI didn't include the statistics for the year 2022, the researcher consider using the available data for the year 2021. A very big decrease of crop

production was observed in this year. The reduction was observed on the following crops: Maize, Cassava, Rice, Ordinary Beans, Climbing Beans, Peas, Vegetables, Soybeans, Banana, Irish potatoes, Sweet potatoes, Fruits and Coffee (Table 4)

Table 4: Statistics on agricultural Production in 2021

Agricultural production of each Sector per Household				
Year 2021	Nyamabuye	Shyogwe	Cyeza	Total (Kg)
Maize	98	201	242	541
Cassava	267	423	350	1040
Rice	185	78	124	387
Ordinary Beans	232	213	45	490
Climbing Beans	231	245	260	736
Peas	4	32	34	70
Vegetables	1201	1200	1122	3523
Soybeans	7	3	12	22
Banana	234	349	532	1115
Irish potatoes	45	57	123	225
Sweet potatoes	25	48	79	152
Fruits	11	5	9	25
Coffee	2	3	12	17

Source: Muhanga District and MINAGRI, 2021

1.8.Impacts of LULUC Changes on Agricultural Production.

This research investigated on crops that are greatly changes when crop data of year 2002, year 2012 and year 2021 are compared.

The analysis of those crops data showed that they a huge decrease of the production between 2012 and 2022 and this reduction is associated with LULC Changes in Muhanga City. As indicated in the (Figure 13) many productions of many crop was reduced.

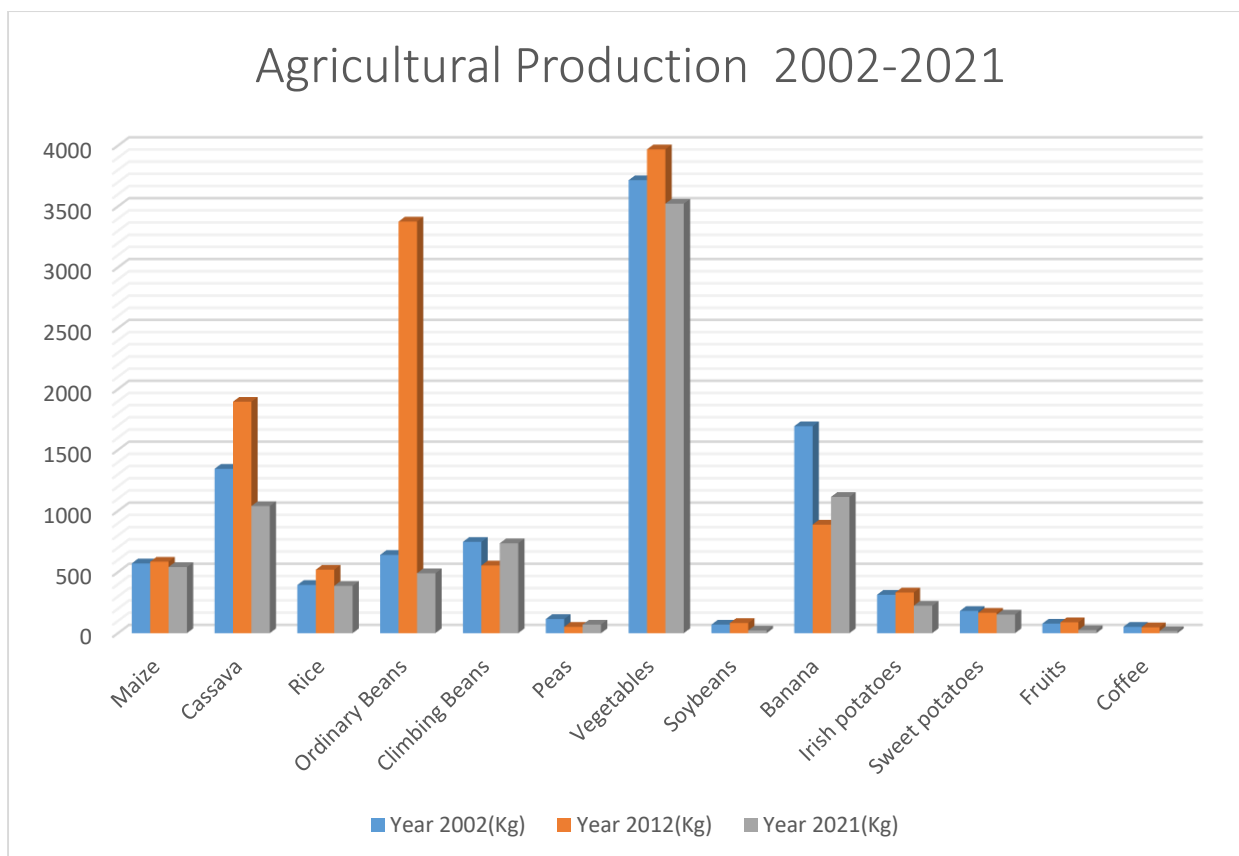


Figure 6: Muhanga City Agricultural Production (in Kg) of specific commodities per Year

2. Discussion

The research results demonstrated that there was a huge change in Land use land cover in Muhanga City and this is common in developed and developing countries where spatial urban expansion is a common phenomenon(Kasraian et al., 2016; Traore et al., 2021). It is associated with economic progression and land development which are seen as engine of city growth which drive the land use land cover (Traore et al., 2021). However, in developing countries urban land use land cover changes are with negative Impacts. Many researchers claimed that The major factors contributing for rapid urban expansion in Africa are higher natural population growth, rural to urban migration and spatial urban development(Nduwayezu et al., 2017). Studies conducted to assess the impact of

Land use land cover in the cities on agricultural Production found that there is a negative impacts of LULC changes on the crop production in developing countries(Elmqvist et al., 2013). LULC studies employed descriptive research design and mix methods of both qualitative and quantitative approaches(Rwanyiziri et al., 2020). Urban expansion program around Rwandan cities city was not participatory. Although urban areas cover a very small fraction of the world’s land surface, rapid urban expansion has significantly changed the Muhanga city landscape and formed immense agricultural and social impacts(MININFRA, 2021). LULC are principally important in rapidly changing areas such as urban settlements in many countries(Mugiraneza et al., 2018a). Over the last decades, several studies have focused on the field of urban expansion.

However, the implications of this the impacts of LULC changes on the agricultural production have not been sufficiently analyzed (Fazal, 2000). They presented some major challenges (Beckers et al., 2020). It was reported that A combination of remotely sensed (RS) data and geographic information systems (GIS) technologies could provide an eminently suitable means of assessing impacts of LULC (Hassan et al., 2016). The next step was to analyze the impacts of LULC changes in Muhanga City between 2002 and 2022, An increased impact of LULC changes on agricultural production was observed.

If the current LULC changes continues in the future, the new urban areas could develop in the fringe and rural areas and, therefore, the trend between rapid urban expansion and limited land resource becomes more apparent and this can continue decreasing the agricultural production (Coulibaly & Li, 2020; Lasisi et al., 2017).

Agricultural agencies should be developing action document plan that may minimize the impacts of LULC Changes on agricultural production is very essential document for rehabilitation program evicted farmers in urban expansion process (Lu et al., 2022; Mugiraneza et al., 2018a)

3. Conclusion

Remotely sensed data are very useful urban studies. Assessing the impacts of land use land cover change on agricultural production in Muhanga city by using remotely sensed data and GIS techniques provides relevant results. This study shows that the LULC Changes has negative impacts on cultivated land and directly and indirectly affects the agriculture production. Remote sensing and

Geographical information systems technologies were applied in this study to process and analysis the geographical data used. There has been rapid conversion of cultivated land used for farming or agriculture to nonagricultural use; spatial expansion has occurred around the city of Muhanga. The study also revealed that the study area has lost some 22.3% (1365.75 ha) of cultivated land to urbanization (Built-up) between 2002 and 2022. At the same time built-up has gain some 16.9 % (1034.58 ha) This study had assessed and found that LULC Changes has adversely affected the agricultural production; over 20 last years, Many crops yields were reduced as follow Maize reduced from 571 Kg to 541kg, Cassava from 1345 to 1040 kg, Rice from 394.7 to 387 kg, Ordinary Beans from 640.6 to 490 kg, Climbing Beans from 747 to 736 kg, Peas from 116 ha to 70 kg, Vegetables from 3716 kg to 3523 kg, Soybeans from 70 kg to 22 kg, Banana from 1695 kg to 1115 kg, Irish potatoes from 313.9 to 225 kg, Sweet potatoes from 181.9 kg to 152 kg, Fruits from 78 to 89kg and Coffee 52 to 17 kg. The Z.test results was $z > 0.05$ which reads to the research hypotheses to be accepted, this means that LULC changes have negatively affected agricultural production based on the reduction of cultivable land and the statistics we have from The District and MINAGRI on the crop in the period of study. Continuous monitoring of land use land cover changes and their impacts are still recommended.

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